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the normal and truncated normal test cycle, calculate the water energy consumption,  $W$ , expressed in kilowatt-hours per cycle and defined as:

$$W = V \times T \times K$$

Where,

$V$  = water consumption in gallons per cycle, as determined in section 5.3.1 of this Appendix,

$T$  = nominal water heater temperature rise = 90 °F,

$K$  = specific heat of water in kilowatt-hours per gallon per degree Fahrenheit = 0.0024.

5.4.2 *Dishwashers that operate with a nominal inlet water temperature of 120 °F.* For the normal and truncated normal test cycle, calculate the water energy consumption,  $W$ , expressed in kilowatt-hours per cycle and defined as:

$$W = V \times T \times K$$

Where,

$V$  = water consumption in gallons per cycle, as determined in section 5.3.1 of this Appendix,

$T$  = nominal water heater temperature rise = 70 °F,

$K$  = specific heat of water in kilowatt-hours per gallon per degree Fahrenheit = 0.0024.

5.5 *Water energy consumption per cycle using gas-heated or oil-heated water.*

5.5.1 *Dishwashers that operate with a nominal 140 °F inlet water temperature, only.*

For each test cycle, calculate the water energy consumption using gas-heated or oil-heated water,  $W_g$ , expressed in Btu's per cycle and defined as:

$$W_g = V \times T \times C/e$$

Where,

$V$  = reported water consumption in gallons per cycle, as determined in section 5.3.2 of this Appendix,

$T$  = nominal water heater temperature rise = 90 °F,

$C$  = specific heat of water in Btu's per gallon per degree Fahrenheit = 8.2,

$e$  = nominal gas or oil water heater recovery efficiency = 0.75.

5.5.2 *Dishwashers that operate with a nominal inlet water temperature of 120 °F.* For each test cycle, calculate the water energy consumption using gas heated or oil heated water,  $W_g$ , expressed in Btu's per cycle and defined as:

$$W_g = V \times T \times C/e$$

Where,

$V$  = reported water consumption in gallons per cycle, as determined in section 5.3.2 of this Appendix,

$T$  = nominal water heater temperature rise = 70 °F,

$C$  = specific heat of water in Btu's per gallon per degree Fahrenheit = 8.2,

$e$  = nominal gas or oil water heater recovery efficiency = 0.75.

5.6 *Annual standby energy consumption.* Calculate the estimated annual standby energy consumption. First determine the number of standby hours per year,  $H_s$ , defined as:

$$H_s = H - (N \times L).$$

Where,

$H$  = the total number of hours per year = 8766 hours per year,

$N$  = the representative average dishwasher use of 215 cycles per year,

$L$  = the average of the duration of the normal cycle and truncated normal cycle, for non-soil-sensing dishwashers with a truncated normal cycle; the duration of the normal cycle, for non-soil-sensing dishwashers without a truncated normal cycle; the average duration of the sensor light response, truncated sensor light response, sensor medium response, truncated sensor medium response, sensor heavy response, and truncated sensor heavy response, for soil-sensing dishwashers with a truncated cycle option; the average duration of the sensor light response, sensor medium response, and sensor heavy response, for soil-sensing dishwashers without a truncated cycle option.

Then calculate the estimated annual standby power use,  $S$ , expressed in kilowatt-hours per year and defined as:

$$S = S_m \times ((H_s)/1000)$$

Where,

$S_m$  = the average standby power in watts as determined in section 4.4 of this Appendix.

[68 FR 51900, Aug. 29, 2003]

### APPENDIX D TO SUBPART B OF PART 430—UNIFORM TEST METHOD FOR MEASURING THE ENERGY CONSUMPTION OF CLOTHES DRYERS

#### 1. Definitions

1.1 "AHAM" means the Association of Home Appliance Manufacturers.

1.2 "Bone dry" means a condition of a load of test clothes which has been dried in a dryer at maximum temperature for a minimum of 10 minutes, removed and weighed before cool down, and then dried again for 10-minute periods until the final weight change of the load is 1 percent or less.

1.3 "Compact" or compact size" means a clothes dryer with a drum capacity of less than 4.4 cubic feet.

1.4 "Cool down" means that portion of the clothes drying cycle when the added gas or electric heat is terminated and the clothes continue to tumble and dry within the drum.

1.5 "Cycle" means a sequence of operation of a clothes dryer which performs a clothes drying operation, and may include variations or combinations of the functions of heating, tumbling and drying.

1.6 "Drum capacity" means the volume of the drying drum in cubic feet.

1.7 "HLD-1" means the test standard promulgated by AHAM and titled "AHAM Performance Evaluation Procedure for Household Tumble Type Clothes Dryers", June 1974, and designated as HLD-1.

1.8 "HLD-2EC" means the test standard promulgated by AHAM and titled "Test Method for Measuring Energy Consumption of Household Tumble Type Clothes Dryers," December 1975, and designated as HLD-2EC.

1.9 "Standard size" means a clothes dryer with a drum capacity of 4.4 cubic feet or greater.

1.10 "Moisture content" means the ratio of the weight of water contained by the test load to the bone-dry weight of the test load, expressed as a percent.

1.11 "Automatic termination control" means a dryer control system with a sensor which monitors either the dryer load temperature or its moisture content and with a controller which automatically terminates the drying process. A mark or detent which indicates a preferred automatic termination control setting must be present if the dryer is to be classified as having an "automatic termination control." A mark is a visible single control setting on one or more dryer controls.

1.12 "Temperature sensing control" means a system which monitors dryer exhaust air temperature and automatically terminates the dryer cycle.

1.13 "Moisture sensing control" means a system which utilizes a moisture sensing element within the dryer drum that monitors the amount of moisture in the clothes and automatically terminates the dryer cycle.

## 2. Testing Conditions

2.1 *Installation.* Install the clothes dryer in accordance with manufacturer's instructions. The dryer exhaust shall be restricted by adding the AHAM exhaust simulator described in 3.3.5 of HLD-1. All external joints should be taped to avoid air leakage. Disconnect all console light or other lighting systems on the clothes dryer which do not consume more than 10 watts during the clothes dryer test cycle.

2.2 *Ambient temperature and humidity.* Maintain the room ambient air temperature at  $75 \pm 3^\circ\text{F}$  and the room relative humidity at  $50 \pm 10$  percent relative humidity.

2.3 *Energy supply.*

2.3.1 *Electrical supply.* Maintain the electrical supply at the clothes dryer terminal block within 1 percent of 120/240 or 120/208Y or 120 volts as applicable to the particular terminal block wiring system and within 1 percent of the nameplate frequency as specified by the manufacturer. If the dryer has a dual voltage conversion capability, conduct test at the highest voltage specified by the manufacturer.

2.3.2 *Gas supply.*

2.3.2.1 *Natural gas.* Maintains the gas supply to the clothes dryer at a normal inlet test pressure immediately ahead of all controls at 7 to 10 inches of water column. If the clothes dryer is equipped with a gas appliance pressure regulator, the regulator outlet pressure at the normal test pressure shall be approximately that recommended by the manufacturer. The hourly Btu rating of the burner shall be maintained within  $\pm 5$  percent of the rating specified by the manufacturer. The natural gas supplied should have a heating value of approximately 1,025 Btu's per standard cubic foot. The actual heating value,  $H_n$ , in Btu's per standard cubic foot, for the natural gas to be used in the test shall be obtained either from measurements made by the manufacturer conducting the test using a standard continuous flow calorimeter as described in 2.4.6 or by the purchase of bottled natural gas whose Btu rating is certified to be at least as accurate a rating as could be obtained from measurements with a standard continuous flow calorimeter as described in 2.4.6.

2.3.2.2 *Propane gas.* Maintain the gas supply to the clothes dryer at a normal inlet test pressure immediately ahead of all controls at 11 to 13 inches of water column. If the clothes dryer is equipped with a gas appliance pressure regulator, the regulator outlet pressure at the normal test pressure shall be approximately that recommended by the manufacturer. The hourly Btu rating of the burner shall be maintained within  $\pm 5$  percent of the rating specified by the manufacturer. The propane gas supplied should have a heating value of approximately 2,500 Btu's per standard cubic foot. The actual heating value,  $H_p$ , in Btu's per standard cubic foot, for the propane gas to be used in the test shall be obtained either from measurements made by the manufacturer conducting the test using a standard continuous flow calorimeter as described in 2.4.6 or by the purchase of bottled gas whose Btu rating is certified to be at least as accurate a rating as could be obtained from measurement with a standard continuous calorimeter as described in 2.4.6.

2.4 *Instrumentation.* Perform all test measurements using the following instruments as appropriate.

2.4.1 *Weighing scale for test cloth.* The scale shall have a range of 0 to a maximum of 30 pounds with a resolution of at least 0.2 ounces and a maximum error no greater than 0.3 percent of any measured value within the range of 3 to 15 pounds.

2.4.1.2 *Weighing scale for drum capacity measurements.* The scale should have a range of 0 to a maximum of 500 pounds with resolution of 0.50 pounds and a maximum error no greater than 0.5 percent of the measured value.

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2.4.2 *Kilowatt-hour meter.* The kilowatt-hour meter shall have a resolution of 0.001 kilowatt-hours and a maximum error no greater than 0.5 percent of the measured value.

2.4.3 *Gas meter.* The gas meter shall have a resolution of 0.001 cubic feet and a maximum error no greater than 0.5 percent of the measured value.

2.4.4 *Dry and wet bulb psychrometer.* The dry and wet bulb psychrometer shall have an error no greater than  $\pm 1$  °F.

2.4.5 *Temperature.* The temperature sensor shall have an error no greater than  $\pm 1$  °F.

2.4.6 *Standard Continuous Flow Calorimeter.* The Calorimeter shall have an operating range of 750 to 3,500 Btu per cubic feet. The maximum error of the basic calorimeter shall be no greater than 0.2 percent of the actual heating value of the gas used in the test. The indicator readout shall have a maximum error no greater than 0.5 percent of the measured value within the operating range and a resolution of 0.2 percent of the full scale reading of the indicator instrument.

2.5 *Lint trap.* Clean the lint trap thoroughly before each test run.

### 2.6 *Test cloths.*

2.6.1 *Energy test cloth.* The energy test cloth shall be clean and consist of the following:

(a) Pure finished bleached cloth, made with a momie or granite weave, which is a blended fabric of 50 percent cotton and 50 percent polyester and weighs within  $\pm 10$  percent of 5.75 ounces per square yard after test cloth preconditioning and has 65 ends on the warp and 57 picks on the fill. The individual warp and fill yarns are a blend of 50 percent cotton and 50 percent polyester fibers.

(b) Cloth material that is 24 inches by 36 inches and has been hemmed to 22 inches by 34 inches before washing. The maximum shrinkage after five washes shall not be more than four percent on the length and width.

(c) The number of test runs on the same energy test cloth shall not exceed 25 runs.

2.6.2 *Energy stuffer cloths.* The energy stuffer cloths shall be made from energy test cloth material and shall consist of pieces of material that are 12 inches by 12 inches and have been hemmed to 10 inches by 10 inches before washing. The maximum shrinkage after five washes shall not be more than four percent on the length and width. The number of test runs on the same energy stuffer cloth shall not exceed 25 runs after test cloth preconditioning.

### 2.6.3 *Test Cloth Preconditioning.*

A new test cloth load and energy stuffer cloths shall be treated as follows:

(1) Bone dry the load to a weight change of  $\pm 1$  percent, or less, as prescribed in Section 1.2.

(2) Place test cloth load in a standard clothes washer set at the maximum water

fill level. Wash the load for 10 minutes in soft water (17 parts per million hardness or less), using 6.0 grams of AHAM Standard Test Detergent, IIA, per gallon of water. Wash water temperature is to be controlled at  $140 \pm 5$  °F ( $60 \pm 2.7$  °C). Rinse water temperature is to be controlled at  $100 \pm 5$  °F ( $37.7 \pm 2.7$  °C).

(3) Rinse the load again at the same water temperature.

(4) Bone dry the load as prescribed in Section 1.2 and weigh the load.

(5) This procedure is repeated until there is a weight change of one percent or less.

(6) A final cycle is to be a hot water wash with no detergent, followed by two warm water rinses.

### 2.7 *Test loads.*

2.7.1 *Compact size dryer load.* Prepare a bone-dry test load of energy cloths which weighs 3.00 pounds  $\pm 0.03$  pounds. Adjustments to the test load to achieve the proper weight can be made by the use of energy stuffer cloths, with no more than five stuffer cloths per load. Dampen the load by agitating it in water whose temperature is  $100 \pm 5$  °F and consists of 0 to 17 parts per million hardness for approximately two minutes in order to saturate the fabric. Then, extract water from the wet test load by spinning the load until the moisture content of the load is between 66.5 percent to 73.5 percent of the bone-dry weight of the test load.

2.7.2 *Standard size dryer load.* Prepare a bone-dry test load of energy cloths which weighs 7.00 pounds  $\pm 0.07$  pounds. Adjustments to the test load to achieve the proper weight can be made by the use of energy stuffer cloths, with no more than five stuffer cloths per load. Dampen the load by agitating it in water whose temperature is  $100 \pm 5$  °F and consists of 0 to 17 parts per million hardness for approximately two minutes in order to saturate the fabric. Then, extract water from the wet test load by spinning the load until the moisture content of the load is between 66.5 percent to 73.5 percent of the bone-dry weight of the test load.

2.7.3 *Method of loading.* Load the energy test cloths by grasping them in the center, shaking them to hang loosely and then dropping them in the dryer at random.

2.8 *Clothes dryer preconditioning.* Before any test cycle, operate the dryer without a test load in the non-heat mode for 15 minutes or until the discharge air temperature is varying less than 1 °F for 10 minutes, whichever is longer, in the test installation location with the ambient conditions within the specified rest condition tolerances of 2.2.

## 3. *Test Procedures and Measurements*

3.1 *Drum capacity.* Measure the drum capacity by sealing all openings in the drum except the loading port with a plastic bag, and ensure that all corners and depressions are filled and that there are no extrusions of

the plastic bag through the opening in the drum. Support the dryer's rear drum surface on a platform scale to prevent deflection of the dryer, and record the weight of the empty dryer. Fill the drum with water to a level determined by the intersection of the door plane and the loading port. Record the temperature of the water and then the weight of the dryer with the added water and then determine the mass of the water in pounds. Add or subtract the appropriate volume depending on whether or not the plastic bag protrudes into the drum interior. The drum capacity is calculated as follows:

$C=w/d$

$C$ = capacity in cubic feet.

$w$ = weight of water in pounds.

$d$ = density of water at the measured temperature in pounds per cubic feet.

3.2 *Dryer loading.* Load the dryer as specified in 2.7.

3.3 *Test cycle.* Operate the clothes dryer at the maximum temperature setting and, if equipped with a timer, at the maximum time setting and dry the test load until the moisture content of the test load is between 2.5 percent to 5.0 percent of the bone-dry weight of the test load, but do not permit the dryer to advance into cool down. If required, reset the timer or automatic dry control.

3.4 *Data recording.* Record for each test cycle:

3.4.1 Bone-dry weight of the test load described in 2.7.

3.4.2 Moisture content of the wet test load before the test, as described in 2.7.

3.4.3 Moisture content of the dry test load obtained after the test described in 3.3.

3.4.4 Test room conditions, temperature and percent relative humidity described in 2.2.

3.4.5 For electric dryers—the total kilowatt-hours of electric energy,  $E_t$ , consumed during the test described in 3.3.

3.4.6 For gas dryers:

3.4.6.1 Total kilowatt-hours of electrical energy,  $E_{te}$ , consumed during the test described in 3.3.

3.4.6.2 Cubic feet of gas per cycle,  $E_{tg}$ , consumed during the test described in 3.3.

3.4.6.3 On gas dryers using a continuously burning pilot light—the cubic feet of gas,  $E_{pg}$ , consumed by the gas pilot light in one hour.

3.4.6.4 Correct the gas heating value, GEF, as measured in 2.3.2.1 and 2.3.2.2, to standard pressure and temperature conditions in accordance with U.S. Bureau of Standards, circular C417, 1938. A sample calculation is illustrated in Appendix E of HLD-1.

3.5 *Test for automatic termination field use factor credits.* Credit for automatic termination can be claimed for those dryers which meet the requirements for either temperature-sensing control, 1.12, or moisture sensing control, 1.13, and having present the appropriate mark or detent feed defined in 1.11.

#### 4. Calculation of Derived Results From Test Measurements

4.1 *Total per-cycle electric dryer energy consumption.* Calculate the total electric dryer energy consumption per cycle,  $E_{cc}$ , expressed in kilowatt-hours per cycle and defined as:

$$E_{cc}=[66/(W_w - W_d)] \times E_t \times FU$$

$E_t$ =the energy recorded in 3.4.5.

66=an experimentally established value for the percent reduction in the moisture content of the test load during a laboratory test cycle expressed as a percent.

FU=Field use factor.

=1.18 for time termination control systems.

=1.04 for automatic control systems which meet the requirements of the definitions for automatic termination controls in 1.11.1, 1.12 and 1.13.

$W_w$ =the moisture content of the wet test load as recorded in 3.4.2.

$W_d$ =the moisture content of the dry test load as recorded in 3.4.3.

4.2 *Per-cycle gas dryer electrical energy consumption.* Calculate the gas dryer electrical energy consumption per cycle,  $E_{ge}$ , expressed in kilowatt-hours per cycle and defined as:

$$E_{ge}=[66/(W_w - W_d)] \times E_{te} \times FU$$

$E_{te}$ =the energy recorded in 3.4.6.1

FU, 66,  $W_w$ ,  $W_d$  as defined in 4.1

4.3 *Per-cycle gas dryer gas energy consumption.* Calculate the gas dryer gas energy consumption per cycle,  $E_{ge}$ , expressed in Btu's per cycle as defined as:

$$E_{gg}=[66/(W_w - W_d)] \times E_{tg} \times FU \times GEF$$

$E_{tg}$ =the energy recorded in 3.4.6.2

GEF=corrected gas heat value (Btu per cubic feet) as defined in 3.4.6.4

FU, 66,  $W_w$ ,  $W_d$  as defined in 4.1

4.4 *Per-cycle gas dryer continuously burning pilot light gas energy consumption.* Calculate the gas dryer continuously burning pilot light gas energy consumption per cycle,  $E_{up}$ , expressed in Btu's per cycle and defined as:

$$E_{up}=E_{pg} \times (8760 - 140/416) \times GEF$$

$E_{pg}$ =the energy recorded in 3.4.6.3

8760=number of hours in a year

416=representative average number of clothes dryer cycles in a year

140=estimated number of hours that the continuously burning pilot light is on during the operation of the clothes dryer for the representative average use cycle for clothes dryers (416 cycles per year)

GEF as defined in 4.3

4.5 *Total per-cycle gas dryer gas energy consumption expressed in Btu's.* Calculate the total gas dryer energy consumption per cycle,  $E_g$ , expressed in Btu's per cycle and defined as:

$$E_g=E_{gg}+E_{up}$$

$E_{gg}$  as defined in 4.3

$E_{up}$  as defined in 4.4

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4.6 *Total per-cycle gas dryer energy consumption expressed in kilowatt-hours.* Calculate the total gas dryer energy consumption per cycle,  $E_{cg}$ , expressed in kilowatt-hours per cycle and defined as:

$$E_{cg} = E_{gc} + (E_g/3412 \text{ Btu/k Wh})$$

$E_{gc}$  as defined in 4.2

$E_g$  as defined in 4.5

[46 FR 27326, May 19, 1981]

### APPENDIX E TO SUBPART B OF PART 430—UNIFORM TEST METHOD FOR MEASURING THE ENERGY CONSUMPTION OF WATER HEATERS

#### 1. Definitions

1.1 *Cut-in* means the time when or water temperature at which a water heater control or thermostat acts to increase the energy or fuel input to the heating elements, compressor, or burner.

1.2 *Cut-out* means the time when or water temperature at which a water heater control or thermostat acts to reduce to a minimum the energy or fuel input to the heating elements, compressor, or burner.

1.3 *Design Power Rating* means the nominal power rating that a water heater manufacturer assigns to a particular design of water heater, expressed in kilowatts or Btu (kJ) per hour as appropriate.

1.4 *Energy Factor* means a measure of water heater overall efficiency.

1.5 *First-Hour Rating* means an estimate of the maximum volume of "hot" water that a storage-type water heater can supply within an hour that begins with the water heater fully heated (i.e., with all thermostats satisfied). It is a function of both the storage volume and the recovery rate.

1.6 *Heat Trap* means a device which can be integrally connected or independently attached to the hot and/or cold water pipe connections of a water heater such that the device will develop a thermal or mechanical seal to minimize the recirculation of water due to thermal convection between the water heater tank and its connecting pipes.

#### 1.7 *Instantaneous Water Heaters*

1.7.1 *Electric Instantaneous Water Heater* Reserved.

1.7.2 *Gas Instantaneous Water Heater* means a water heater that uses gas as the energy source, initiates heating based on sensing water flow, is designed to deliver water at a controlled temperature of less than 180 °F (82 °C), has an input greater than 50,000 Btu/h (53 MJ/h) but less than 200,000 Btu/h (210 MJ/h), and has a manufacturer's specified storage capacity of less than 2 gallons (7.6 liters). The unit may use a fixed or variable burner input.

1.8 *Maximum gpm (L/min) Rating* means the maximum gallons per minute (liters per minute) of hot water that can be supplied by

an instantaneous water heater while maintaining a nominal temperature rise of 77 °F (42.8 °C) during steady state operation.

1.9 *Rated Storage Volume* means the water storage capacity of a water heater, in gallons (liters), as specified by the manufacturer.

1.10 *Recovery Efficiency* means the ratio of energy delivered to the water to the energy content of the fuel consumed by the water heater.

1.11 *Standby* means the time during which water is not being withdrawn from the water heater. There are two standby time intervals used within this test procedure:  $\tau_{\text{stby},1}$  represents the elapsed time between the time at which the maximum mean tank temperature is observed after the sixth draw and subsequent recovery and the end of the 24-hour test;  $\tau_{\text{stby},2}$  represents the total time during the 24-hour simulated use test when water is not being withdrawn from the water heater.

#### 1.12 *Storage-type Water Heaters*

1.12.1 *Electric Storage-type Water Heater* means a water heater that uses electricity as the energy source, is designed to heat and store water at a thermostatically controlled temperature of less than 180 °F (82 °C), has a nominal input of 12 kilowatts (40,956 Btu/h) or less, and has a rated storage capacity of not less than 20 gallons (76 liters) nor more than 120 gallons (450 liters).

1.12.2 *Gas Storage-type Water Heater* means a water heater that uses gas as the energy source, is designed to heat and store water at a thermostatically controlled temperature of less than 180 °F (82 °C), has a nominal input of 75,000 Btu (79 MJ) per hour or less, and has a rated storage capacity of not less than 20 gallons (76 liters) nor more than 100 gallons (380 liters).

1.12.3 *Heat Pump Water Heater* means a water heater that uses electricity as the energy source, is designed to heat and store water at a thermostatically controlled temperature of less than 180 °F (82 °C), has a maximum current rating of 24 amperes (including the compressor and all auxiliary equipment such as fans, pumps, controls, and, if on the same circuit, any resistive elements) for an input voltage of 250 volts or less, and, if the tank is supplied, has a manufacturer's rated storage capacity of 120 gallons (450 liters) or less. Resistive elements used to provide supplemental heating may use the same circuit as the compressor if (1) an interlocking mechanism prevents concurrent compressor operation and resistive heating or (2) concurrent operation does not result in the maximum current rating of 24 amperes being exceeded. Otherwise, the resistive elements and the heat pump components must use separate circuits. A heat pump water heater may be sold by the manufacturer with or without a storage tank.

a. *Heat Pump Water Heater with Storage Tank* means an air-to-water heat pump sold